

WHAT IS CLAIMED IS:

1. An operation state determining apparatus for determining an operation state of a fuel cell battery formed by stacking a plurality of unit cells each having a construction in which a wet-state solid electrolyte membrane is sandwiched between an anode that is supplied with a fuel gas and a cathode that is supplied with an oxidizing gas, comprising:

a voltage measuring portion that measures a voltage of at least one of the unit cells or a voltage of a unit cell stack formed by stacking a plurality of unit cells; and

an operation state determining portion which determines that the operation state of the fuel cell is a first operation state that is one of a low fuel gas state and a dried-up state if the voltage measured by the voltage measuring portion is within a predetermined inappropriate voltage range, and is below a predetermined voltage that is pre-set at a low value that is substantially impossible during a low oxidizing gas state and during a flooded state, and which determines that the operation state of the fuel cell is a second operation state that is one of the low oxidizing gas state and the flooded state if the voltage measured by the voltage measuring portion is within the inappropriate voltage range, and is above the predetermined voltage.

2. The operation state determining apparatus according to claim 1, wherein the operation state determining portion determines which one of the first operation state and the second operation state is the operation state based on voltages measured by the voltage measuring portion a plurality of times during a period of a predetermined determination time after it is determined that a voltage measured by the voltage measuring portion is within the inappropriate voltage range.

3. The operation state determining apparatus according to claim 1, wherein if the operation state is the second operation state, the operation state determining portion determines that the operation state is the flooded state, when the voltage drops and the duration of that voltage drop is short, and the operation state determining portion determines that the operation state is the low oxidizing gas state, when the duration is long.

4. The operation state determining apparatus according to claim 1, further comprising an impedance measuring portion that measures an impedance of at least one of the unit cells or an impedance of the unit cell stack,

wherein if the operation state of the fuel cell is the first operation state and the

impedance measured by the impedance measuring portion is not within a predetermined appropriate impedance range, the operation state determining portion determines that the operation state is the dried-up state, and wherein if the operation state of the fuel cell is the first operation state and the impedance measured by the impedance measuring portion is within the predetermined appropriate impedance range, the operation state determining portion determines that the operation state is the low fuel gas state.

5. The operation state determining apparatus according to claim 1, wherein the predetermined voltage is set at a value that is at most 0 [V].

6. An operation state determining method for determining an operation state of a fuel cell battery formed by stacking a plurality of unit cells each having a construction in which a wet-state solid electrolyte membrane is sandwiched between an anode that is supplied with a fuel gas and a cathode that is supplied with an oxidizing gas, comprising:

(a) the step of determining whether a voltage of at least one of the unit cells or a voltage of a unit cell stack formed by stacking a plurality of unit cells is within a predetermined inappropriate voltage range;

(b) the step of determining whether the voltage is below a predetermined voltage that is pre-set at a low value that is substantially impossible during a low oxidizing gas state and during a flooded state; and

(c) the step of determining that the operation state of the fuel cell is a first operation state that is one of a low fuel gas state and a dried-up state if the voltage is within the inappropriate voltage range, and is below the predetermined voltage, and determining that the operation state of the fuel cell is a second operation state that is one of the low oxidizing gas state and the flooded state if the voltage is within the inappropriate voltage range, and is above the predetermined voltage.

7. The operation state determining method according to claim 6, further comprising (d) the step of determining whether an impedance of at least one of the unit cells or an impedance of the unit cell stack is within a predetermined appropriate impedance range,

wherein, in the step (c), if the operation state of the fuel cell is the first operation state and the impedance is not within a predetermined appropriate impedance range, it is determined that the operation state is the dried-up state, and wherein, in the step (c), if the operation state of the fuel cell is the first operation state and the impedance is within the

predetermined appropriate impedance range, it is determined that the operation state is the low fuel gas state.

8. An operation state determining apparatus for determining an operation state of a fuel cell battery formed by stacking a plurality of unit cells each having a construction in which a wet-state solid electrolyte membrane is sandwiched between an anode that is supplied with a fuel gas and a cathode that is supplied with an oxidizing gas, comprising:

an impedance measuring portion that measures an impedance of at least one of the unit cells or an impedance of a unit cell stack formed by stacking a plurality of unit cells;

a voltage measuring portion that measures a voltage of at least one of the unit cells or a voltage of the unit cell stack; and

an operation state determining portion that determines which one of a low fuel gas state, a low oxidizing gas state, a flooded state and a dried-up state is the operation state based on the impedance measured by the impedance measuring portion and the voltage measured by the voltage measuring portion.

9. The operation state determining apparatus according to claim 8, wherein the operation state determining portion determines which one of the low fuel gas state, the low oxidizing gas state, the flooded state and the dried-up state is the operation state based on impedances measured by the impedance measuring portion a plurality of times and voltages measured by the voltage measuring portion a plurality of times during a period of a predetermined determination time after it is determined that a voltage measured by the voltage measuring portion is within a predetermined inappropriate voltage range.

10. The operation state determining apparatus according to claim 8, wherein the operation state determining portion determines that the operation state is the dried-up state if the impedance measured by the impedance measuring portion is not a predetermined appropriate impedance.

11. The operation state determining apparatus according to claim 10, wherein if the impedance measured by the impedance measuring portion is the appropriate impedance, the operation state determining portion determines which one of the low fuel gas state, the low oxidizing gas state and the flooded state is the operation state of the fuel cell based on the voltage measured by the voltage measuring portion.

12. The operation state determining apparatus according to claim 10, wherein the operation state determining portion determines that the operation state is the low fuel gas state if the impedance measured by the impedance measuring portion is the appropriate impedance and the voltage measured by the voltage measuring portion is below a predetermined voltage that is pre-set at a low value that is substantially impossible during the low oxidizing gas state and during the flooded state.

13. The operation state determining apparatus according to claim 12, wherein the predetermined voltage is set at a value that is at most 0 [V].

14. The operation state determining apparatus according to claim 8, wherein the operation state determining portion determines that the operation state of the fuel cell is the flooded state in a case where the voltage measured by the voltage measuring portion drops into a predetermined inappropriate voltage range, but remains above a predetermined voltage that is pre-set at a low value that is substantially impossible during the low oxidizing gas state and during the flooded state, and the duration of the voltage drop is short.

15. The operation state determining apparatus according to claim 8, wherein the operation state determining portion determines that the operation state of the fuel cell is the low oxidizing gas state in a case where the voltage measured by the voltage measuring portion drops into a predetermined inappropriate voltage range, but remains above a predetermined voltage that is pre-set at a low value that is substantially impossible during the low oxidizing gas state and during the flooded state, and the duration of the voltage drop is long.

16. An operation state determining method for determining an operation state of a fuel cell battery formed by stacking a plurality of unit cells each having a construction in which a wet-state solid electrolyte membrane is sandwiched between an anode that is supplied with a fuel gas and a cathode that is supplied with an oxidizing gas, comprising the steps of:

measuring an impedance of at least one of the unit cells or an impedance of a unit cell stack formed by stacking a plurality of unit cells;

measuring a voltage of at least one of the unit cells or a voltage of the unit cell stack;

and

determining which one of a low fuel gas state, a low oxidizing gas state, a flooded state and a dried-up state is the operation state based on the impedance and the voltage.

17. An operation state determining apparatus for determining an operation state of a fuel cell battery formed by stacking a plurality of unit cells each having a construction in which a wet-state solid electrolyte membrane is sandwiched between an anode that is supplied with a fuel gas and a cathode that is supplied with an oxidizing gas, comprising:

a voltage measuring portion that measures a voltage of at least one of the unit cells or a voltage of a unit cell stack formed by stacking a plurality of unit cells; and

a operation state determining portion which determines that there is a possibility of the operation state being a low oxidizing gas state if the voltage measured by the voltage measuring portion is at most a first predetermined voltage, and is at least a second predetermined voltage that is smaller than the first predetermined voltage, and which determines that there is a possibility of the operation state being a low fuel gas state if the voltage measured by the voltage measuring portion is at most the second predetermined voltage.

18. The operation state determining apparatus according to claim 17, further comprising an impedance measuring portion that measures an impedance of at least one of the unit cells or an impedance of the unit cell stack,

wherein the operation state determining portion determines that the operation state is the dried-up state if the voltage measured by the voltage measuring portion is at most the second predetermined voltage and the impedance measured by the impedance measuring portion is not within an appropriate impedance range.

19. The operation state determining apparatus according to claim 17, wherein the operation state determining portion determines that the operation state of the fuel cell is the flooded state in a case where the voltage measured by the voltage measuring portion drops between the first predetermined voltage and the second predetermined voltage, and the duration of the voltage drop is short.

20. An operation state determining method for determining an operation state of a fuel cell battery formed by stacking a plurality of unit cells each having a construction in which a wet-state solid electrolyte membrane is sandwiched between an anode that is supplied

with a fuel gas and a cathode that is supplied with an oxidizing gas, comprising the steps of:

measuring a voltage of at least one of the unit cells or a voltage of a unit cell stack formed by stacking a plurality of unit cells; and

determining that there is a possibility of the operation state being a low oxidizing gas state if the voltage is at most a first predetermined voltage, and is at least a second predetermined voltage that is smaller than the first predetermined voltage, and determining that there is a possibility of the operation state being a low fuel gas state if the voltage is at most the second predetermined voltage.